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Evaluation of relationship between type of body shape assessed using waist-to-hip ratio, and occurrence of cardiovascular risk factors in patients with acute coronary syndrome

Magdalena Dudzikowska[1,A-C,E-F], Dorota Rębak[1,C-D,F], Jarosław Chmielewski[2,A-F], Joanna Gotlib-Małkowska[3,B-D], Radosław Sierpiński[4,D-F], Maciej Janusz Żerdziński[5,B-C], Marek Łyp[6,D-F], Małgorzata Goździewska[7,E-F]

[1] *Department of Public Health, Collegium Medicum, Jan Kochanowski University, Kielce, Poland*
[2] *Department of Public Health, Academy of Medical Sciences of Applied and Holistic Sciences, Warsaw, Poland*
[3] *Department of Education and Research in Health Sciences, Faculty of Health Science, Medical University, Warsaw, Poland*
[4] *National Center for Health Policy and Research on Health Inequalities, Cardinal Stefan Wyszynski University, Warsaw, Poland*
[5] *Faculty of Medical Sciences, Silesian University, Katowice, Poland*
[6] *Faculty of Medical Sciences, Medical Academy of Applied Sciences, Warsaw, Poland*
[7] *Departament of Medical Anthropology, Institute of Rural Health, Lublin, Poland*
A – Research concept and design, B – Collection and/or assembly of data, C – Data analysis and interpretation, D – Writing the article, E – Critical revision of the article, F – Final approval of the article

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Abstract

Introduction and Objective. Morbidity due to cardiovascular diseases (CVD), including acute coronary syndrome (ACS) is closely related with the presence of risk factors. Obesity causes changes in body composition and constitutes a CVD risk factor on the population level. The aim of the study is to evaluate the relationship between the type of body shape measured by waist-to-hip ratio (WHR), and the occurrence of cardiovascular risk factors in patients with ACS.
Materials and Method. The study included 253 patients with the first event of ACS hospitalized in the 2nd Cardiology Clinic at the Kielce Province Cardiology Centre, Poland, using the following methods: analysis of records, estimation, anthropometric measurements, and laboratory tests.
Results. The analyzed group of males and females was characterized by significantly more frequent occurrence of overweight and obesity with an android body shape. It was also observed that patients with an android body type had a higher concentration of triglycerides in blood plasma. Arterial hypertension and type 2 diabetes also more often concerned patients with an android body type.
Conclusions. The results obtained allow the presumption that the determination of fatty tissue distribution is useful while assessing the risk of carbohydrate and lipid metabolism disorders. Despite the type of body shape determined in a patient it exerts an effect on the change of metabolism, and additionally predisposes to the occurrence of arterial hypertension and type 2 diabetes.

Key words
risk factors, cardiovascular diseases, WHR

INTRODUCTION

Epidemiological studies clearly indicate that morbidity due to cardiovascular diseases (CVDs), including acute coronary syndrome (ACS), is closely related with the presence of risk factors. Risk factors diagnosed in patients with ACS may be divided into two main groups: modifiable (change in life style, treatment undertaken, implementation of preventive actions), and non-modifiable (age, gender, genetic burden, concomitant diseases). Limitation of the occurrence of modifiable risk factors for CVD by a change in life style decreases the occurrence of each type of ACS [1, 2].

Epidemiological studies conducted to-date confirm the presence of deficiency of knowledge concerning correct health behaviours and knowledge of CVD risk factors. Prophylactic actions and health education carried out at each stage of treatment should provide knowledge about risk factors, and prepare patients for the modification of life style [2].

Arterial hypertension is one of the risk factors for CVD. The World Health Organization (WHO) reports that over a billion adults suffer from arterial hypertension, which constitutes more than 20% of the world population; therefore,

✉ Address for correspondence: Małgorzata Goździewska, Departament of Medical Anthropology, Institute of Rural Health, Lublin, Jaczewskiego 2, 20-090 Lublin, Poland
E-mail: malgorzata.gozdziewska@gmail.com

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this disease is classified into the group of civilisation diseases. It is estimated that among the European population this problem concerns 45% of adults. The probability of developing arterial hypertension increases with age. According to the epidemiological data, in Poland, hypertension concerns 32–36% of adults [3].

The subsequent important risk factor for CVD is dyslipidaemia, especially the concentration of low-density lipoprotein (LDL) cholesterol level which, according to the current guidelines by the European Society of Cardiology (ESC), is the most important component assessed in the lipidogram. The initial level of LDL and category of cardiovascular risk will be a basis for intensity of actions concerning the change in life style and pharmacotherapy regarding individual patients. Documented ACS automatically qualifies the patient to the category at very high cardiovascular risk, where the aim should be striving towards the level of LDL < 1.8 mmol/l (70 mg/dl), or reduction by at least 50% if the initial level was 1.8–3.5 mmol/l (70–135 mg/dl) [4].

Persons ill with type 2 diabetes are also at an increased risk of CVD. The most frequent cause of death in adults with diabetes are CVDs caused by atherosclerosis, microangiopathy, diabetic cardiomyopathy, and cardiac autonomic neuropathy. Prevention of hyperglycaemia decreases the risk of vascular complications, and thus reduces the risk for CVD. According to the guidelines by the ESC, non-pregnant women with type 1 or type 2 diabetes should maintain the level of HbA1c < 7% (< 53 mmol/mol). Such actions aim at decreasing an overall risk for CVD and microangiopathy [4, 5].

Overweight or obesity may exert an adverse effect on cholesterol and triglyceride metabolism, while high-density lipoprotein (HDL), and LDL affect arterial hypertension and may cause insulin resistance. The risk for CVD and development of type 2 diabetes increases with body mass index (BMI). Obesity causes alternations in body composition, which may affect the haemodynamics of the heart, and also change the structure of the heart muscle. Adipose tissue produces pro-inflammatory cytokines which may contribute to the development of arrhythmias and promote the formation of atherosclerotic plaques. Also, an abnormally elevated BMI increases the risk of cancerous diseases concerning the large intestine, breast, prostate, endometrium, kidneys, and urinary bladder. Therefore, in order to achieve optimum health on an individual level, the aim is to maintain a BMI of 18.5–24.9 kg/m^2 [6].

In order to determine the type of obesity the WHR ratio is used, which specifies if the patient has android obesity (WHR > 0.8 in females, WHR > 1 in males), or gynoid obesity (WHR < 0.8 in females, WHR < 1 in males). It is a complement to the BMI index [7].

Central obesity (android, visceral, abdominal obesity) manifests itself in an increase in visceral fat tissue, its accumulation in the abdominal cavity disproportionate to the whole body. Excessive abdominal fat causes an increase in the level of free fatty acid (FFA) as a result of enhanced lipolytic activity. This leads to an increased accumulation of FFA in inappropriate sites, such as the liver and skeletal muscles, which ultimately leads to metabolic disorders, and development of insulin resistance and dyslipidaemia [8, 9].

Overweight and obesity are associated with an increased risk of death due to CVD, and overall mortality. Maintenance of normal body weight exerts a beneficial effect on metabolic CVD risk factors, such as: arterial blood pressure, dyslipidaemia, and venous plasma glucose concentration. Change in life style in terms of diet and physical activity and behavioural modifications should be the basis for the treatment of overweight or obesity [10, 11].

OBJECTIVE

The objective of the study was assessment of the frequency of occurrence of risk factors for CVD, and the relationship between the type of body shape measured by WHR, and the occurrence of cardiovascular risk factors in patients with ACS.

MATERIALS AND METHOD

The study included 345 patients with ACS treated in the 2nd Cardiology Clinic at the Kielce Province Cardiology Centre in Kielce, Poland, in 2020. The following criteria were adopted for inclusion into the study group: patients with the first ACS incident – unstable angina (UA), non-ST-segment elevation myocardial infarction (NSTEMI), ST-segment elevation myocardial infarction (STEMI). The criteria of exclusion were: another ACS incident, physical inefficiency which makes anthropometric measurements impossible, mental dysfunction impairing the state of consciousness, and patients undergoing anti-cancer therapy. A total of 253 patients were ultimately qualified for the study group.

The mean age of patients was 63.39 (±9.54); 59.3% (n=150) of the study population were males. BMI in the examined population was 28.99 (±4.72)kg/m^2, on average; WHR – 0.96 (±0.09). As many as 86.2% (n=218) of the patients in the study had an android body shape. The mean body weight was 80.51 (±15.64)kg; 42.3% (n=107) of patients were overweight, while 36.4% (n=92) were obese. The most common type of acute coronary syndrome was UA – 38.7% in 98 patients (Tab. 1).

The following methods were applied in the study: analysis of records, estimation, anthropometric measurements, and laboratory tests, while the techniques used in order to obtain the desired data were: qualitative and quantitative data analyses, comparison of data to the reference values, measurements of body weight and height, waist and hip circumference, and biochemical blood tests. Anthropometric measurement and blood sampling for tests took place in the morning, in fasting patients, after a night's rest.

The risk factors considered in the study were: overweight, obesity, arterial hypertension, nicotine addiction, hypercholesterolaemia (diagnosed before hospitalization or in the course of treatment), impaired fasting glucose, glucose intolerance, type 2 diabetes, alcohol dependence syndrome, B-type natriuretic peptide (or brain natriuretic peptide), and estimated glomerular filtration rate using the Modification of Diet in Renal Disease (MDRD).

Statistical analysis was performed using: mean value, median, standard deviation (SD), the first and third quartile values (IQR) and range, Shapiro-Wilk test, t-Student test, Mann-Whitney U test; unit odd ratios (OR) were calculated based on logistic regression model. The significance level was set at p=0.05.

Table 1. Characteristics of the study group – demographic data, anthropometric measurements, type of acute coronary syndrome

Variable	Parameter	Total (N=253)
Age	N	253
	$\bar{x}$ (SD)	63.39 (9.54)
	Me (IQR)	65 (59–70)
	Range	37–79
Age	≥65	50.6% (n=128)
	<65	49.4% (n=125)
Gender	Male	59.3% (n=150)
	Female	40.7% (n=103)
BMI [kg/m²]	N	253
	$\bar{x}$ (SD)	28.99 (4.72)
	Me (IQR)	28.24 (25.43–31.76)
	Range	19.73–47.13
BMI [kg/m²]	Normal	21.3% (n=54)
	Overweight	42.3% (n=107)
	Obese	36.4% (n=92)
WHR	N	253
	$\bar{x}$ (SD)	0.96 (0.09)
	Me (IQR)	0.97 (0.89–1.02)
	Range	0.76–1.3
Type of body shape	Android	86.2% (n=218)
	Gynoid	13.8% (n=35)
Body weight [kg]	N	253
	$\bar{x}$ (SD)	80.51 (15.64)
	Me (IQR)	79.4 (68.9–88.4)
	Range	48.3–139.6
Acute coronary syndrome (ACS)	UA	38.7% (n=98)
	NSTEMI	28.5% (n=72)
	STEMI	32.8% (n=83)

RESULTS

The mean total cholesterol level in the examined population was 190.93 (±51.55)mg/dL. The mean level of LDL cholesterol was 118.83 (±42.74)mg/dL. In 31.2% (n=79) of patients LDL level exceeded 135 mg/dL, in 32.4% (n=82) of patients the level of triglycerides was ≥150 mg/dL. The mean BNP value in the examined population was 178.69 (±200.32) pg/mL, in more than a half of patients (54.2%, n=137) the BNP level was above reference values. Regarding the remaining variables concerning laboratory tests the majority of the examined patients had results within the range of reference values. The most common CVD risk factors in the examined population were: arterial hypertension (65.6%, n=166), and hypercholesterolaemia (49.8%, n=126) (Tab. 2).

Assessment of the relationship between the type of body shape and occurrence of risk factors. After the study group had been divided according to WHR, it was found that android body shape more often occurred in males (66.1%, n=144), whereas the gynoid type – in females (82.9%, n=29; p<0.001). Persons with normal body weight definitely more frequently had a gynoid body shape (51.4%, n=18), whereas those overweight most often had an android body type (44.5%, n=97; p<0.001). A higher level of triglycerides in blood plasma was observed in patients with android body shape (p=0.0103), while higher values of HDL cholesterol were noted in those with gynoid body type (p<0.001). Type 2 diabetes significantly more often occurred in patients with android body shape (p=0.0136) (Tab. 3).

Assessment of the relationship between the type of body shape, patient gender, and occurrence of risk factors. The analyzed group of males was characterized by significantly more frequent occurrence of overweight or obesity with android body shape (p=0.0029) (Fig. 1). No other significant differences were observed in this group.

In the group of females obesity with android type of body shape was significantly more frequently observed, whereas females with gynoid body shape more often had normal body weight (50%, n=37 vs 44.8%, n=13; p<0.001). Females with android body shape had a higher level of triglycerides in blood plasma (p=0.0099), whereas in the group with gynoid body shape a higher level of HDL cholesterol was noted (p=0.018). Arterial hypertension and type 2 diabetes more often concerned females with android body shape (p=0.0347; p=0.0188) (Tab. 4).

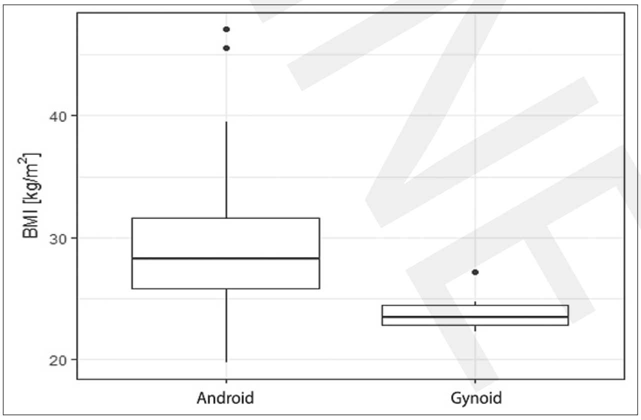

Figure 1. Comparison of results of BMI [kg/m²] according to the division into types of body shape in males

Assessment of the relationship between the type of body shape, patient's age, and occurrence of risk factors. The largest group of patients aged ≥65 were males with android body shape, while females in this age group were characterized by the gynoid type (p<0.001). It was observed that among older patients, those with ACS and gynoid body shape had a normal body weight, whereas the majority of patients with android body were overweight (46.4%, n=52) or obese (36.6%, n=41; p=0.01). Higher level of HDL cholesterol was observed in older patients with ACS and gynoid body shape (p=0.0093). No other significant differences were observed in the analyzed group (Tab. 5).

In the group of patients with ACS aged under 65, males with android body shape prevailed (p<0.001). In this age group, overweight (42.5%, n=45) and obesity (41.5%, n=44)

Table 2. Characteristics of the study group – occurrence of risk factors and results of laboratory tests

Variable	Parameter	Total (N=253)
Total cholesterol [mg/dL]	N	253
	$\bar{x}$ (SD)	190.93 (51.55)
	Me (IQR)	186 (155–227)
	Range	72–337
LDL cholesterol [mg/dL]	N	253
	$\bar{x}$ (SD)	118.83 (42.74)
	Me (IQR)	116 (86–144)
	Range	29–249
Triglycerides [mg/dL]	N	253
	$\bar{x}$ (SD)	142.98 (88.55)
	Me (IQR)	122 (93–167)
	Range	39–834
HDL cholesterol [mg/dL]	N	253
	$\bar{x}$ (SD)	44.98 (12.36)
	Me (IQR)	44 (37–51)
	Range	13–101
BNP [pg/mL]	N	253
	$\bar{x}$ (SD)	178.69 (200.32)
	Me (IQR)	111 (54–245)
	Range	5–1386
MDRD [mL/min/1.73 m^2]	N	253
	$\bar{x}$ (SD)	72.06 (17.03)
	Me (IQR)	72.3 (61.2–82)
	Range	28.8–188.2
Total cholesterol [mg/dL]	>200	36.8% (n=93)
	130–200	53.4% (n=135)
	<130	9.9% (n=25)

Variable	Parameter	Total (N=253)
LDL cholesterol [mg/dL]	>135	31.2% (n=79)
	70–135	55.3% (n=140)
	<70	13.4% (n=34)
Triglycerides [mg/dL]	≥150	32.4% (n=82)
	<150	67.6% (n=171)
HDL cholesterol [mg/dL]	Within reference range	53.8% (n=136)
	No	46.2% (n=117)
BNP [pg/mL]	≤100	45.8% (n=116)
	>100	54.2% (n=137)
MDRD [mL/min/1.73 m^2]	≥90	11.5% (n=29)
	60–89	65.6% (n=166)
	<60	22.9% (n=58)
Arterial hypertension	Yes	65.6% (n=166)
	No	34.4% (n=87)
Nicotine addiction	Yes	30.8% (n=78)
	No	69.2% (n=175)
Hypercholesterolaemia	Yes	49.8% (n=126)
	No	50.2% (n=127)
Impaired fasting glucose	Yes	20.9% (n=53)
	No	79.1% (n=200)
Glucose intolerance	Yes	4.7% (n=12)
	No	95.3% (n=241)
Type 2 diabetes	Yes	21.3% (n=54)
	No	78.7% (n=199)
Alcohol dependence syndrome	Yes	2% (n=5)
	No	98% (n=248)

Table 3. Comparison of selected parameters according to the type of body shape

Variable	Parameter	Android (n=218)	Gynoid (n=35)	test	p
Gender	Male	66.1% (n=144)	17.1% (n=6)	chi-square	<0.001
	Female	33.9% (n=74)	82.9% (n=29)		
BMI [kg/m^2]	Normal	16.5% (n=36)	51.4% (n=18)	chi-square	<0.001
	Overweight	44.5% (n=97)	28.6% (n=10)		
	Obesity	39% (n=85)	20% (n=7)		
Triglycerides [mg/dL]	N	218	35	Mann-Whitney U	0.0103
	$\bar{x}$ (SD)	148.11 (92.46)	111.03 (48.31)		
	Me(IQR)	127.5 (95–170)	106 (79–131.5)		
	Range	42–834	39–233		
HDL cholesterol [mg/dL]	N	218	35	Mann-Whitney U	<0.001
	$\bar{x}$ (SD)	43.92 (12.09)	51.57 (12.19)		
	Me(IQR)	43 (36–49.75)	52 (43.5–58.5)		
	Range	13–101	26–78		
Type 2 diabetes	Yes	23.9% (n=52)	5.7% (n=2)	Fisher's	0.0136
	No	76.1% (n=166)	94.3% (n=33)		

were more frequently observed in patients with android type (p=0.001). A higher level of triglycerides in the younger age group was found in patients with android body shape (p=0.0222), whereas HDL cholesterol in blood plasma was noted in patients with gynoid type (p=0.0156) (Tab. 6).

Assessment of the relationship between the type of body shape, type of ACS, and occurrence of risk factors. In the group of patients with ACS UA, it was only observed that males significantly more often had an android body shape (p=0.0063). In the group of patients with ACS NSTEMI,

Table 4. Comparison of selected parameters according to the type of body shape in the examined females

Variable	Parameter	Android (n=74)	Gynoid (n=29)	test	p
BMI [kg/m^2]	Normal	10.8% (n=8)	44.8% (n=13)	chi-square	**<0.001**
	Overweight	39.2% (n=29)	31% (n=9)		
	Obesity	50% (n=37)	24.1% (n=7)		
Triglycerides [mg/dL]	n	74	29	Mann-Whitney U	**0.0099**
	$\bar{x}$ (SD)	158.35 (84.49)	115.31 (50.9)		
	Me(IQR)	139 (106–174.75)	108 (82–141)		
	Range	61–559	39–233		
HDL cholesterol [mg/dL]	n	74	29	Mann-Whitney U	**0.018**
	$\bar{x}$ (SD)	47.12 (13.62)	53.03 (12.43)		
	Me (IQR)	45 (37.25–52)	53 (44–61)		
	Range	21–101	26–78		
Arterial hypertension	Yes	78.4% (n=58)	55.2% (n=16)	chi-square	**0.0347**
	No	21.6% (n=16)	44.8% (n=13)		
Type 2 diabetes	Yes	28.4% (n=21)	6.9% (n=2)	Fisher's	**0.0188**
	No	71.6% (n=53)	93.1% (n=27)		

Table 5. Comparison of the selected parameters according to the type body shape in patients aged 65 and over

Variable	Parameter	Android (n=112)	Gynoid (n=16)	test	p
Gender	Male	57.1% (n=64)	12.5% (n=2)	Fisher's	<0.001
	Female	42.9% (n=48)	87.5% (n=14)		
BMI [kg/m2]	Normal	17% (n=19)	50% (n=8)	Fisher's	0.01
	Overweight	46.4% (n=52)	18.8% (n=3)		
	Obese	36.6% (n=41)	31.2% (n=5)		
HDL cholesterol [mg/dL]	n	112	16	t-Student	0.0093
	$\bar{x}$ (SD)	43.76 (11.25)	53 (12.05)		
	Median (IQR)	44 (35.75–51)	53 (44–59.25)		
	Range	22–76	32–78		

Table 6. Comparison of the selected parameters according to the type of body shape in patients aged under 65

Variable	Parameter	Android (n=106)	Gynoid (n=19)	test	p
Gender	Male	75.5% (n=80)	21.1% (n=4)	Fisher	<0.001
	Female	24.5% (n=26)	78.9% (n=15)		
BMI [kg/m2]	Normal	16% (n=17)	52.6% (n=10)	Fisher	0.001
	Overweight	42.5% (n=45)	36.8% (n=7)		
	Obesity	41.5% (n=44)	10.5% (n=2)		
Triglycerides [mg/dL]	n	106	19	Mann-Whitney U	0.0222
	$\bar{x}$ (SD)	166.08 (108.36)	114.79 (52.63)		
	Me(IQR)	137 (103.5–195)	98 (75.5–151)		
	Range	46–834	39–233		
HDL cholesterol[mg/dL]	n	106	19	Mann-Whitney U	0.0156
	$\bar{x}$ (SD)	44.08 (12.97)	50.37 (12.5)		
	Me (IQR)	41.5 (37–48)	49 (40.5–57)		
	Range	13–101	26–76		

a significantly higher triglycerides level was observed in those with android type (p=0.0044) (Fig. 2), whereas patients with gynoid body shape had higher HDL cholesterol level (p=0.0403) (Fig. 3).

Among patients with ACS STEMI, males with android body shape dominated (p<0.001). In this group, patients with gynoid type body shape more often had normal body weight (p<0.001). Higher values of HDL cholesterol were observed in persons with gynoid body shape (p=0.0076). Patients with ACS STEMI and android body shape had estimated glomerular filtration rate calculated using the MDRD equation within the normal range (p=0.0225). Similar to

Table 7. Comparison of the selected parameters according to the type of body shape in patients with ACS STEMI

Variable	Parameter	Android (n=70)	Gynoid (n=13)	test	p
Gender	Male	77.1% (n=54)	15.4% (n=2)	Fisher's	<0.001
	Female	22.9% (n=16)	84.6% (n=11)		
BMI [kg/m²]	Normal	14.3% (n=10)	76.9% (n=10)	Fisher's	<0.001
	Overweight	47.1% (n=33)	7.7% (n=1)		
	Obesity	38.6% (n=27)	15.4% (n=2)		
HDL cholesterol [mg/dL]	n	70	13	t-Student	0.0076
	$\bar{x}$ (SD)	40.43 (9.19)	49.69 (10.19)		
	Me (IQR)	39.5 (34.25–47)	50 (41–54)		
	Range	21–63	37–71		
MDRD [mL/min/1.73 m²]	n	70	13	t-Student	0.0372
	$\bar{x}$ (SD)	74.88 (15.03)	64.65 (14.96)		
	Me (IQR)	75.7 (66.83–84.35)	61.4 (51.1–80.2)		
	Range	40.6–112.8	43.9–83.6		
LDL cholesterol [mg/dL]	>135	31.4% (n=22)	69.2% (n=9)	Fisher's	0.043
	70–135	54.3% (n=38)	23.1% (n=3)		
	<70	14.3% (n=10)	7.7% (n=1)		
MDRD [mL/min/1.73 m²]	≥90	17.1% (n=12)	0% (n=0)	Fisher's	0.0225
	60–89	67.1% (n=47)	53.8% (n=7)		
	<60	15.7% (n=11)	46.2% (n=6)		

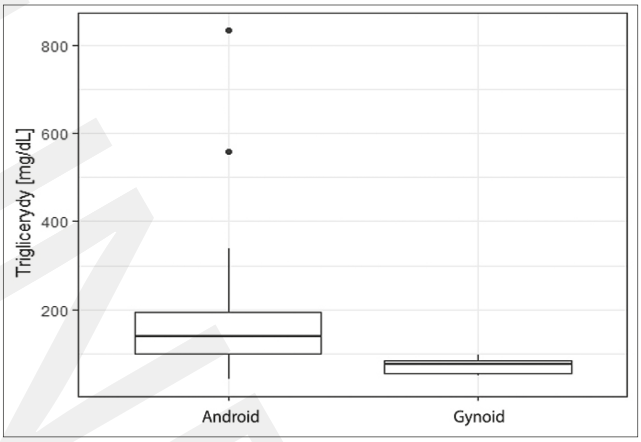

Figure 2. Comparison of the parameter triglycerides [mg/dL] according to the type of body shape in patients with NSTEMI

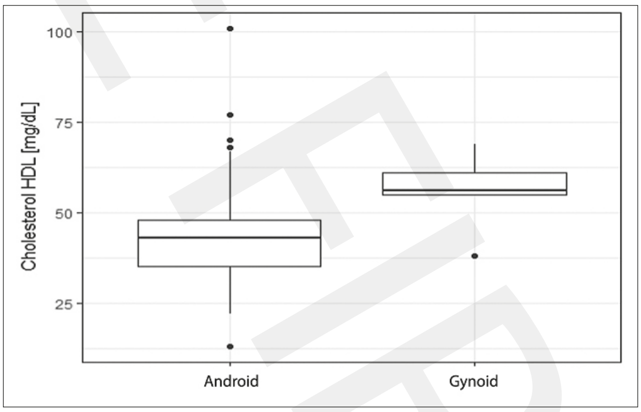

Figure 3. Comparison of the parameter HDL cholesterol [mg/dL] according to the type of body shape in patients with NSTEMI

other divisions, higher HDL cholesterol values were found among patients with gynoid body shape (p=0.0076). LDL cholesterol level in blood serum within the normal range was significantly more frequently noted in patients with android type (p=0.043) (Tab. 7).

DISCUSSION

The results of the study are in line with the growing scientific evidence indicating that the distribution of fatty tissue, and not its amount, is involved in the determination of cardiovascular risk. Especially the android type of body shape characterized by the prevalence of visceral adipose tissue co-occurred with clearly worse lipid profile, greater insulin resistance and increased inflammatory condition, which is the basis of the pathophysiology of atherosclerosis and acute coronary syndromes (ACS) [12, 13].

In the analyzed population of patients with ACS the mean LDL level was 118.83 ± 42.74 mg/dL, whereas in 31.2% of patients this level exceeded 135 mg/dL. These results are consistent with contemporary European registries, where the values of LDL after admission due to ACS most often remain within the range 10–130 mg/dL, despite earlier diagnosis of hypercholesterolaemia [14, 15]. According to the recommendations by 2023 ESC concerning ACS and 2021 ESC regarding cardiovascular prevention, all patients who had undergone ACS were qualified into the category at very high risk with target level of LDL<55 mg/dL, and a reduction by ≥50%, compared to the baseline [14, 16]. In this context, the observed LDL values indicate that a considerable part of patients prior to ACS did not achieve current therapeutic goals.

The mean level of total cholesterol (190.93 ± 51.55 mg/dL) and a significant percentage of patients with triglycerides (≥150 mg/dL, 32.4%) indicate a frequent co-occurrence of atherogenic dyslipidaemia. The current opinions by ESC/EAS (European Society of Cardiology/ European Atherosclerosis Society) emphasize that hypertriglyceridemia and the presence of small, dense LDL particles are particularly characteristic of visceral obesity and insulin resistance [17]. The MERIFACS (Metabolic Risk Factors In First Acute Coronary Syndrome) study covering patients with the first event of ACS showed a similar percentage of hypertriglyceridemia (approx. 30–35%), which was interpreted by the researchers as a reflection of metabolic disorders preceding the clinical manifestation of coronary heart disease [18]. Also, a 2025 case-control analysis emphasized that the co-occurrence of arterial hypertension, dyslipidaemia, and unfavourable anthropometric parameters significantly increased the risk of ACS, even with moderately elevated LDL level [19].

In the examined group, arterial hypertension occurred in 65.6% of patients, while hypercholesterolaemia in 49.8%, which corresponds to the structure of risk factors in European populations of patients with ACS [14, 16]. The 2021 ESC guidelines emphasize the synergistic effect of hypertension, dyslipidaemia and central obesity on destabilization of atherosclerotic plaque by enhancing oxidative stress, endothelial dysfunction and activation of the inflammatory axis [16].

An important element of the results obtained is an elevated BNP level – more than a half of patients (54.2%) had values exceeding the reference range, and the mean concentration at 178.69 ± 200.32 pg/mL. According to the ESC recommendations regarding heart failure, an elevated BNP level in the acute phase of ACS is an independent prognostic factor of adverse cardiovascular events [20]. Literature on the subject also emphasizes the relationship between metabolic disorders and intensification of the neurohormonal response in the acute phase of myocardial ischaemia [21]. This may suggest that the metabolic profile of patients – potentially related with the distribution of adipose tissue – exerts an effect not only on the risk of development of ACS, but also on its early haemodynamic severity.

The results obtained show that the examined population is characterized by a risk profile typical of contemporary European cohorts: elevated LDL, common hypertriglyceridemia, and high prevalence of arterial hypertension. In the context of WHR assessment analyzed in this study it will be especially substantial to determine whether an unfavourable distribution of adipose tissue co-occurs with the intensification of lipid disorders and neurohormonal response, which might confirm the importance of central obesity as a high cardiovascular risk phenotype.

The study confirmed a significant relationship between the type of adipose tissue distribution and metabolic profile of patients with the first event of ACS. The android type of obesity was more frequently observed in males, whereas the gynoid obesity in females ($p<0.001$), which is consistent with hormonal predispositions and known gender differences in the distribution of adipose tissue [16]. The 2021 ESC recommendations emphasize that android obesity – more frequent among males – is related to a higher cardiovascular risk, irrespective of the BMI [16].

In the analyzed group, patients with normal body weight more often presented the gynoid type of obesity, while overweight patients – android obesity ($p<0,001$). This observation is of great clinical importance, because in accordance with the current data, central obesity may also occur in persons with normal BMI (so-called normal weight central obesity), and is related with significantly higher risk for cardiovascular events [22]. Contemporary analyses demonstrate that WHR better reflects metabolic risk than body weight or BMI alone [23]. Patients with android obesity were characterized by a higher level of triglycerides ($p=0.0103$), whereas high HDL levels were observed in the group with gynoid body shape ($p<0.001$). This profile corresponds to the classic image of atherogenic dyslipidaemia associated with visceral obesity, including hypertriglyceridaemia, low HDL, and the presence of small, dense LDL particles [17]. The MERIFACS study showed a similar relationship between central obesity parameters and lipid disorders in patients with the first ACS event [18]. Other contemporary analyses also confirm that the distribution of adipose tissue, and not its total amount, is the determinant of adverse lipid profile [23, 24].

A significantly higher prevalence of type 2 diabetes in the group of patients with android obesity ($p=0.0136$) confirms the metabolic nature of visceral obesity. Visceral adipose tissue shows a high endocrine activity, favouring the development of insulin resistance, chronic inflammatory state, and activation of the renin-angiotensin-aldosterone (RAA) system [16, 24]. This relationship has a direct impact on the risk of destabilization of atherosclerotic plaque and development of ACS, which is confirmed by population analyses [19, 22]. Thus, the results obtained are in line with the current clinical trend, according to which central obesity – assessed using WHR – is a strong metabolic cardiovascular risk phenotype. In the population of patients with the first ACS event android obesity was accompanied by more adverse lipid profile and more frequent co-occurrence of type 2 diabetes, which may indicate its potential role as an indicator of an increased susceptibility to acute manifestation of coronary heart disease.

Analysis performed according to gender demonstrated that in the group of males, overweight or obesity co-occurred significantly more frequently with the android body shape ($p=0.0029$), with the lack of other significant metabolic differences. This information is consistent with physiological predisposition of males to visceral fat distribution which – as confirmed by 2021 ESC guidelines – is related with a higher cardiovascular risk, irrespective of the BMI [16]. In the European populations, it was confirmed that in males central obesity rates more strongly correlate with the risk for ACS than the classic assessment of body weight [14, 16]. Considerably more clear differences were observed in the group of females. Obesity was significantly more often observed in females with android body shape, while normal body weight was more frequently noted among females with gynoid obesity ($p<0.001$). These results are in accordance with the current reports indicating that the loss of protective, gynoid pattern of adipose tissue distribution, especially after menopause, is related with increased metabolic and cardiovascular risk [16, 22]. Population studies emphasize that the transition from gynoid to android body shape is one of the mechanisms of an increase in the risk for ACS in middle-aged and older women females [22, 23]. Females with android body shape were characterized by a higher triglycerides level ($p=0.0099$), and more frequent occurrence of arterial hypertension and type 2 diabetes ($p=0.0347$; $p=0.0188$). Simultaneously, in the group of patients with gynoid obesity a higher HDL level was observed ($p=0.018$). Such a metabolic profile corresponds to the classic atherogenic dyslipidaemia caused by visceral obesity and insulin resistance [17]. This is especially important in females, in whom the presence of central obesity neutralizes partially protective effect of estrogens on lipid metabolism and endothelial function [16, 24]. In the light of current 2023 ESC guidelines concerning ACS, females with concomitant type 2 diabetes and arterial hypertension are the group at especially high risk of adverse cardiovascular events [14]. The results obtained suggest that in the population of females with the first ACS event android body shape may be the phenotype of clearly intensified metabolic risk, more strongly differentiating the profile of risk factors, compared to males.

From the clinical aspect, these observations enhance the importance of the assessment of WHR as the tool for identification of females with especially adverse metabolic profile, and in whom the classic assessment of the BMI may not reflect the actual cardiovascular risk. This is in line with the current trend emphasizing the need for more precise, gender-differentiated risk stratification in coronary heart disease [14, 16].

Age-dependent analysis showed that in the age group ≥65, males with android body shape dominated, while females in this age group presented gynoid body shape ($p<0.001$). This observation partially reflects established gender differences in the distribution of adipose tissue; however, it should be emphasized that with age adipose tissue is redistributed towards the visceral region, especially in post-menopausal women [16]. The 2021 ESC guidelines indicate that ageing is associated with an intensification of insulin resistance, an increase in visceral fat mass, and deterioration of lipid profile, irrespective of the BMI [16]. In the older age group normal body weight was more often observed in patients with gynoid body shape, whereas overweight (46.4%) and obesity (36.6%) dominated among persons with android body shape ($p=0.01$). These results confirm that at an older age android phenotype is frequently accompanied by overweight and adverse metabolic profile. Importantly, higher HDL levels in the group aged ≥65 were observed in patients with gynoid body shape ($p=0.0093$), which is consistent with the protective nature of the peripheral distribution of adipose tissue [17, 23]. The lack of any other significant differences may suggest that in older population a part of metabolic disorders is compensated by widespread pharmacotherapy (statins, antihypertensive treatment), which is observed in the European registries of patients with ACS [14]. In the group aged <65 also dominated males with android body shape ($p<0.001$). In this population overweight (42.5%) and obesity (41.5%) significantly more often concerned patients with android body shape ($p=0,001$), which indicates that in the younger age group, central obesity is a particularly pronounced risk phenotype. In addition, in this age group higher levels of triglycerides were found in persons with android body shape ($p=0.0222$), and higher HDL levels in patients with gynoid body shape ($p=0.0156$). Such a profile corresponds to the classic image of atherogenic dyslipidaemia caused by visceral obesity and insulin resistance [17]. Population analyses show that central obesity at a younger age is related with an earlier clinical manifestation of coronary heart disease and a greater metabolic burden at the time of the first ACS [18, 22]. The MERIFACS study emphasized that patients with the first ACS event often present cumulative metabolic disorders already before the age of 65, and the distribution of adipose tissue plays an important role in this process [18]. The compilation of the results of both age analyses suggests that android body shape co-occurs with an adverse metabolic profile in both the younger and older populations; however, in the age group <65 these relationships seem to be more clear in terms of triglyceridaemia and excess body weight. This may indicate that visceral obesity at a younger age is a stronger factor initiating premature manifestation of ACS, whereas in an older population its effect is partially modulated by treatment and coexisting risk factors.

These findings support the concept that the assessment of WHR may be a useful tool for identification of patients with adverse metabolic phenotype irrespective of age, and may be of special importance in the group of younger patients with the first ACS event.

While analyzing the relationships between the type of body shape and the type of acute coronary syndrome, differences in metabolic profile were confirmed according to the clinical form of ACS. In the group with UA the only significant relationship was more frequent presence of android body shape in males ($p=0.0063$). This observation is consistent with known gender differences in the distribution of adipose tissue and epidemiology of coronary heart disease, where males more often present visceral obesity [14, 16]. The lack of metabolic differences in this sub-group may be due to its smaller size, or the fact that UA is becoming a less and less dominant form of ACS in the era of highly sensitive troponins [14]. In the group with NSTEMI, significantly higher levels of triglycerides were found in patients with android body shape ($p=0.0044$), and higher HDL levels in persons with gynoid body shape ($p=0.0403$). This profile corresponds to the classic image of atherogenic dyslipidaemia accompanying visceral obesity [17]. Contemporary data indicate that in patients with NSTEMI metabolic disorders, including hypertriglyceridaemia and insulin resistance are involved in the progression of multivessel atherosclerosis and inflammatory destabilization of plaques [14, 18]. It may be presumed that in this group the android body shape promotes chronic, metabolism-driven endothelial damage leading to the clinical image of NSTEMI. In the population with STEMI males with android body shape dominated ($p<0.001$), which is consistent with epidemiology of STEMI more frequently observed among males at a younger age [14]. Patients with gynoid body shape more often had a normal body weight ($p<0.001$) and higher HDL levels ($p=0.0076$), which confirms the protective nature of peripheral distribution of adipose tissue [16, 17]. An interesting observation is the fact that normal LDL levels were more often observed in patients with android body shape ($p=0.043$). This phenomenon may reflect limitations of risk assessment based exclusively on LDL. Current guidelines by the ESC emphasize that cardiovascular risk depends not only on absolute LDL level, but also on the quality of lipoprotein particles, presence of hypertriglyceridemia, small, dense LDL, and concomitant metabolic disorders [14, 17]. In persons with visceral obesity a relatively normal LDL-C level may be observed, with a simultaneous presence of highly atherogenic lipid phenotype. In the group with STEMI persons with android body shape more often presented normal values of glomerular filtration rate (MDRD) ($p=0.0225$). This observation may result from the younger age of males with this phenotype, because in populations with STEMI, the patients are younger, on average, than those with NSTEMI [14].

Simultaneously, the potential influence of the so-called obesity paradox should be considered, described in ACS, where higher body weight is sometimes associated with better short-term prognosis, although the mechanisms of this phenomenon remain controversial [18]. Summing up, according to the form of ACS android phenotype was accompanied by adverse metabolic profile, especially in patients with NSTEMI, where hypertriglyceridaemia dominated. In turn, STEMI was observed in a higher percentage of males with android body shape; however, with more frequent normal LDL values, which highlights the limitations of traditional lipid assessment and the potential importance of WHR as an additional risk indicator. The results of this study support the concept that the distribution of adipose tissue can determine the clinical phenotype of ACS and constitute a complementary element to modern risk stratification in accordance with the guidelines by the ESC [14, 16].

In 2024, a meta-analysis was published which included the relationship between WHR and the risk of myocardial infarction, and showed that elevated WHR is more strongly related with the risk of myocardial infarction than the BMI, especially in males and persons aged <65. The above corresponds with the observations regarding the domination of the android phenotype in the younger age group with STEMI/NSTEMI [25]. Also, population studies in groups with ACS indicate that central obesity ratios (WHR, WHtR) correlate with a higher risk of cardiovascular events, and a greater intensification of coronary heart disease, compared to the BMI [26, 27]. Analysis including patients with ACS showed that a higher WHR is related with a higher score according to the GRACE scale, which may suggest a relationship between visceral phenotype and the severity of an acute event [28]. Also, the data are interesting and indicate that WHR remains an independent predictor of cardiovascular risk in patients with diabetes and metabolic syndrome, even with normal LDL level [29]. This may partially explain the phenomenon observed in the analysis of more frequent normal LDL levels in patients with android body shape, despite an adverse metabolic profile. In addition, in 2024, it was confirmed that the indicators of adipose tissue distribution are related with adverse cardiovascular events after past myocardial infarction, and their prognostic value exceeds classic body weight measurements [27]. In the context of the analyses performed in the presented study, this may suggest that WHR coincides with the differences in the risk factor profile and potentially also the prognosis.

The current study has shown that the distribution of adipose tissue assessed using the WHR co-occurs with the differences in the profile of cardiovascular risk factors in patients with the first event of ACS. Android phenotype was accompanied by more frequent occurrence of overweight and obesity, higher level of triglycerides, lower HDL level, and higher frequency of type 2 diabetes and arterial hypertension – irrespective of absolute LDL levels. This was especially clearly observed in patients aged <65 and in the group with NSTEMI, which may indicate that central obesity contributes an earlier, metabolically conditioned manifestation of coronary heart disease. The results obtained confirm that WHR reflects high metabolic risk phenotype, which is fully identified neither by the classic BMI assessment nor the LDL level alone. WHR assessment is a simple, inexpensive tool that can be used routinely, and may supplement modern stratification of risk in patients with ACS, and support the decision concerning intensification of secondary prevention.

Limitations of the study. The study was of an observational and cross-sectional nature which allows the assessment of the co-occurrence of clinical, biochemical, and anthropometric characteristics; however, it does not allow the drawing of cause-and-effect conclusions.

The study was conducted in one centre which may have limited the possibility of generalizing the results to other populations of patients with ACS.

There was a clear numerical imbalance between the WHR groups: the vast majority were patients with android type of adipose tissue distribution, while the group with gynoid body shape was relatively small. Such a disproportion could have limited the statistical power of intergroup comparisons and exerted an effect on the stability of subgroup analyses.

Assessment of the distribution of adipose tissue was based exclusively on WHR, without simultaneous consideration of other indicators of central obesity, such as waist circumference, or waist-to-height ratio which, according to the current literature, also show an important prognostic value.

Some of the potential confounding factors, including previous pharmacotherapy, life style, physical activity, mode of nutrition, or hormonal status of women, were not analyzed in a complex manner.

The study included exclusively patients after the first event of ACS; therefore, the results should be referred to this special clinical population, and interpreted with caution outside this context.

While interpreting the presented results, attention should be paid to the fact that the study was of an observational and cross-sectional character; therefore, it did not allow the assessment of cause-effect relationships, only the identification of co-occurrence of specified clinical and metabolic characteristics and the type of adipose tissue distribution. In addition, imbalance in the size of the android and gynoid groups could have limited the statistical power of a part of comparisons, and exerted an effect on the stability of results of inter-group analyses.

Despite the fact that WHR remains a recognized indicator of fat distribution and cardio-metabolic risk, current research also indicates the great value of waist circumference and WHtR. Therefore, future studies should compare these indicators simultaneously, preferably in multi-centre and prospective projects.

CONCLUSIONS

- In the examined population of patients after the first event of ACS, the most frequent cardiovascular risk factors were arterial hypertension and hypercholesterolaemia.
- The android type of adipose tissue distribution was more often observed in males, while the gynoid type in females.
- The android type of adipose tissue distribution was associated with less favourable metabolic profile, including higher level of triglycerides, and more frequent co-occurrence of type 2 diabetes.
- The results obtained suggest that WHR may be a useful tool supplementing the assessment of metabolic risk in patients with ACS. However, considering the cross-sectional nature

of the study and imbalance in the size of the examined groups, these observations require confirmation in prospective, multi-centre studies, and taking take into account other indicators of central obesity, such as waist circumference and WHtR.

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